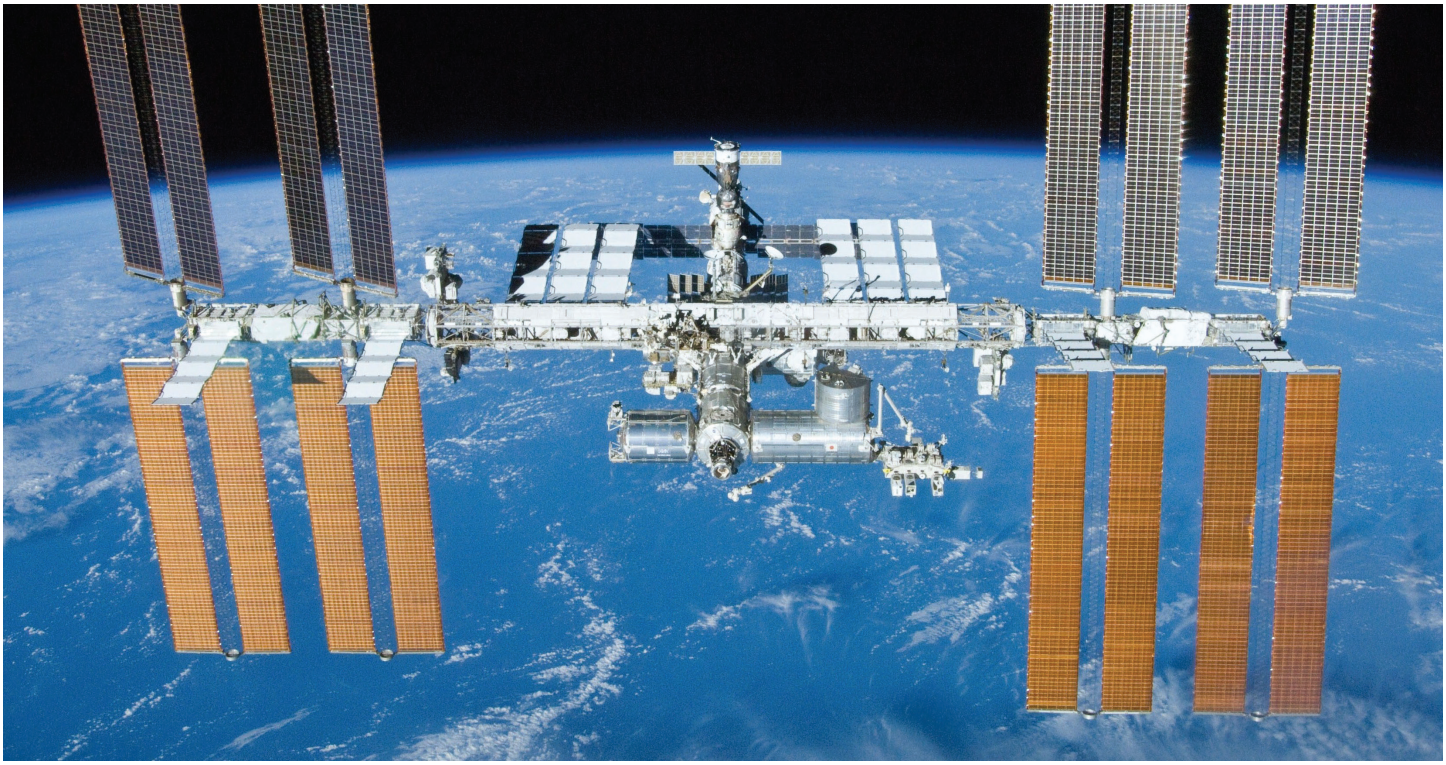
MAGNAPLATE
COATINGS ENGINEERED FOR YOUR SUCCESS

WHITE PAPER

Synergistic Coatings Meet Demanding Aerospace Challenges



Countless NASA vehicles sent into space have used parts coated by Magnaplate, including the parts on the International Space Station (ISS).

Aerospace and airframe manufacturers know how difficult it is to design components that can withstand extreme environments while providing corrosion and wear protection. Making things even more complicated is the need to comply with international standards, such as REACH. While engineers favor composites, aluminum, titanium and magnesium for their light weight, most of these metals are highly susceptible to corrosion if left unprotected. Synergistic surface enhancement coatings can help address and ultimately overcome these challenges.

Unlike “paint-ons” and other less capable surface treatments, synergistic coatings are mechanically cross-linked to become a part of the new surface, creating metal surfaces that offer superior performance to both the original base metal and conventional coatings. This technology offers several problem-solving benefits, including resistance to environmental and chemical corrosion, abrasion, galling, radiation, wear, outgassing and UV rays, as well as permanent dry lubrication, a low coefficient of friction and thermal tolerance.

As with any industry, aerospace has its own unique set of challenges. This white paper will explore what they are, as well as how synergistic coatings can solve them.

Gearing up for the first manned mission to Mars, NASA recently developed its new generation of spacesuit. Synergistic coatings were applied to several areas of the suit, including the gloves—imparting them with the required lubricity while ensuring they stand up to the harsh conditions of outer space.

Avoiding Hazardous Waste

Many aerospace manufacturers, particularly in the United States, are looking to comply with REACH and other international industry standards regarding the reduction of hazardous materials. As a result, companies are looking for alternative solutions to chromium, cadmium and other heavy metals, which, while undergoing certain surface finishing processes, release toxins into the air. When applied to metal surfaces, however, REACH-compliant synergistic coatings impart low friction and corrosion and wear resistance—the same superior properties that once made chromic acid and cyanide plating processes so appealing.

In addition to avoiding hazardous waste production, companies are looking to replace traditional heavy metals to reduce costs. Magnesium alloys, in particular, are gaining popularity for their high strength-to-weight ratio, dimensional stability and low density—which is roughly one-quarter that of steel and two-thirds that of aluminum. For these reasons, magnesium- and aluminum-based alloys can drastically reduce the weight of aircraft, which, in turn, also reduces fuel consumption and CO^2 emissions. At the same time, however, these lighter, cheaper alloys, if left uncoated, are much more susceptible to corrosion, galling and wear.

Resisting Corrosion

Synergistic surface enhancement coatings create harder-than-steel, permanently dry lubricated metal surfaces that are designed to resist corrosion. Tufram® for aluminum and its alloys has a hardness range of Rc 40 to 65, elevating the metal's surface hardness to levels comparable to case-hardened steel. In salt spray testing, Tufram® on high-strength aluminum exceeds the AMS 2482 requirement of 336 hours, while submersion tests in strong acids at 248°F show no effect after more than 170 hours. Magnaplate HCR®, another smart coating solution for aluminum, has the ability to withstand salt spray exposure in excess of 15,000 hours—that's 44 times the MIL-SPEC requirement of 336 hours. As a result of these smart coating solutions, aluminum can essentially replace more expensive substrates like ferrous alloys in many aerospace applications while offering ease in machining.

GENERAL MAGNAPLATE'S AEROSPACE HISTORY

Magnaplate's history is steeped in aerospace. Established in 1952, the company met NASA's need for a new kind of surface technology that could withstand the harsh outgassing conditions of outer space. Since then, Magnaplate's coatings have played a critical role in several military and space-based missions, from drilling on the moon to landing the Curiosity Rover on Mars.

1969

Not only was "man" able to walk on the moon, but thanks to General Magnaplate, he was able to drill into it too. Canadize® treatment on both the inside and outside of the titanium core-sample drill tubes prevented galling and eliminated contamination of the moon rock samples.

1970

Apollo 13 is considered by many to be NASA's finest hour.

1981

As NASA entered more advanced phases of its space program, the agency required technological improvements that provided extremely hard, dry-lubricated surfaces to hundreds of aluminum, titanium and steel parts, tools and other pieces of equipment.

2004

Magnaplate's coatings play a role in the Mars Rover's descent rate limiter.

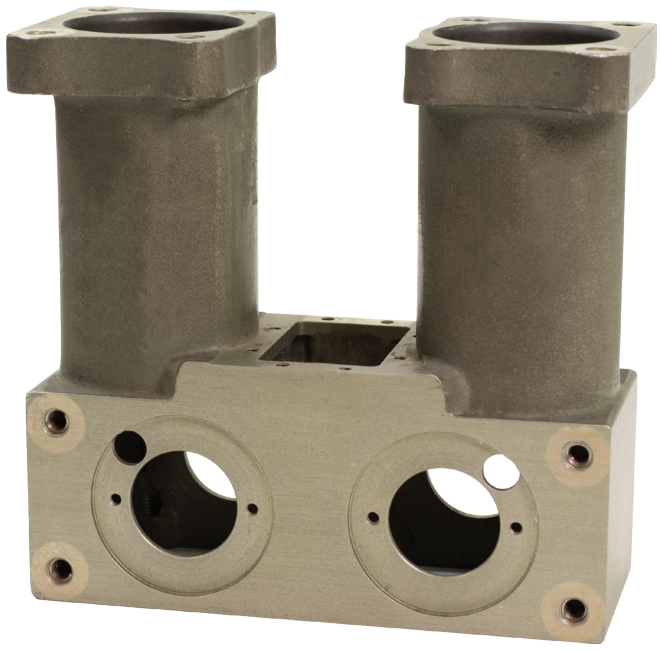
2012

Magnaplate plays a mission-critical role coating parts for commercial spacecraft and NASA's Curiosity Mars rover.

2017

General Magnaplate has been involved for 70 years in the aerospace industry.

2022



Synergistic coatings protected the fuel-mixing control valves on the LEM Ascent Engine of Apollo 13.

Minimizing Friction

Synergistic coatings also protect against abrasion and galling, a form of wear caused by adhesion between sliding metal surfaces especially if there is inadequate lubrication. Metal galling is a common industry problem that affects smaller components like aircraft bearings or the joints and drive shaft of titanium core sample drill tubes. These parts, particularly if they are made from aluminum and titanium alloys, will self-generate an oxide surface film. When bearing fasteners are tightened, for example, pressure builds between the metal surfaces, breaking down the protective oxide coating and generating friction, which can fuse the nut and bolt together. Canadize® for titanium alloys and Magnadize® for magnesium alloys both leave hard, fracture-free coatings that prevent hydrogen absorption from occurring between the metals.

One way to reduce friction is to apply grease or oil to components, however, this course of action requires routine maintenance. Not only are companies looking to make a shift away from lubricants that release harmful particulates into the atmosphere, but they also want to avoid liquid

lubrication that requires constant reapplication—a time-consuming and costly solution. Synergistic coatings, such as Tufram® and Magnaplate HCR® for aluminum alloys, Canadize® for titanium alloys, Magnadize® for magnesium alloys and Nedox® for ferrous and nonferrous base metals, offer an eco-friendly, permanent solution that boasts coefficients of friction as low as 0.05.

Coping With Temperature Extremes

Aerospace components must be able to withstand both high heat and extreme cold while still operating with total reliability. To that end, synergistic coatings feature wide temperature ranges, ensuring surface protection in a variety of thermal environments, including the harsh vacuum and low temperatures of outer space. Plasmadize®, an infused matrix of metals, ceramics, proprietary polymers and dry lubricants, for example, boasts an impressive operating range of -200° to 1,300°F. Our several coating variations, which consists of either solvent- or water-based formulas, can withstand temperatures up to 1,000°F. In addition to being able to withstand the high heat, this multi-dimensional family of coatings provides easy mold and die release at high temperatures and is a perfect fit for composite tooling and autoclaves.

THE FUTURE OF COATINGS: COMPOSITE AIRFRAMES

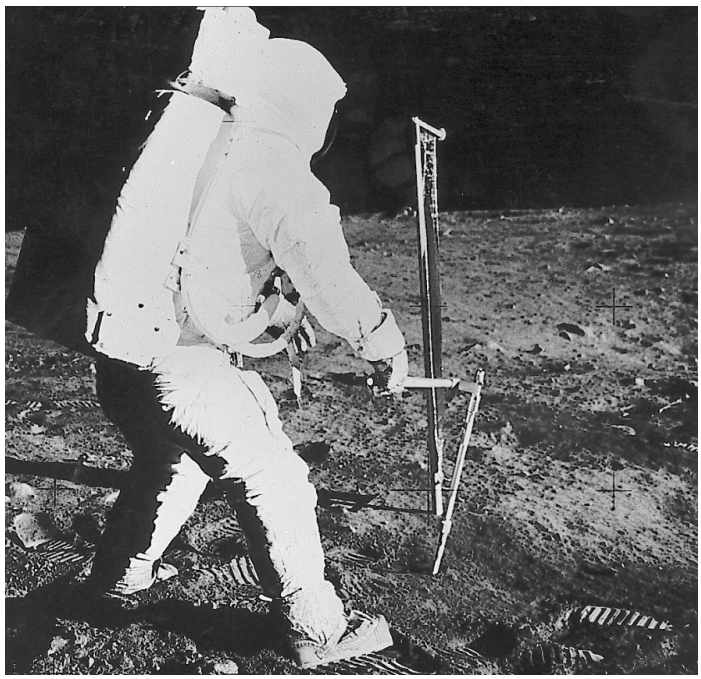
The development of advanced composites is spurring the next generation of high-performance, economical aircraft design. For one, composite airframes are easier to construct than their metal counterparts. The material also makes for a smoother, more aerodynamic and electronically transparent surface that avoids electromagnetic interference (EMI). Composite designs are also lighter, which improves efficiency and reduces fuel consumption and overall aircraft operating costs. Though hardly a new aviation technology, many engineers are not aware of the role coatings can play in maximizing the lifespan of composite airframes.

CURRENT AEROSPACE SUPPORT

General Magnaplate currently works with many commercial airframe and aerospace companies, as well as commercial space craft, airline and military companies to coat components ranging from air conditioning units on jetliners, to hydraulic rotary actuators on military aircraft, to the fuel valves on commercial jets.

Since the beginning of space travel, General Magnaplate has provided smart coating solutions to guard against high temperatures, outgassing and erosion/abrasion during launch and reentry, as well as salt corrosion from the ocean during module recovery.

Today the Company is ISO certified, NADCAP accredited and ITAR complaint and its coatings are REACH compliant.



Contamination can occur from moon surface samples by titanium particles and other foreign materials. Applying synergistic coatings to these drill tubes can make the surfaces abrasion-resistant and permanently dry-lubricated.

RELEASE FOR COMPOSITE TOOLING

Whether tooling is Invar (a nickel-iron alloy) or other metals, synergistic smart coatings provide release without the use of traditional silicon sprays or swabbing. Cleanup of composite parts, before painting, and required tooling is a major factor in savings.

Conclusion

The metal components used in space systems and other aerospace applications must be able to withstand corrosion, wear, friction and thermal extremes. At the same time, companies are looking to replace heavy metals in keeping with strict international standards, as well as save time and money with permanently lubricated solutions that cut down on maintenance costs. Since the very first NASA space missions, synergistic coatings have been up to the challenge, offering corrosion and wear resistance, dry lubrication, thermal tolerance and REACH-compliant protection for steel, aluminum, titanium and other super alloy components.

In 2004, Magnaplate played a critical role in the Mars Rover landing by providing coatings for the landing mechanism.